"Meteorological observations at Emporia," by T. H. Dinsmore.

"A resumé of the crop-weather season of 1893 in Kansas," by T. B. Jennings.

A new aecidium of peculiar habit," by M. A. Carleton.

"The solvent action of acetic acid as a substitute for alcohol," by L. E. Sayre.

"On the comparative value of the hypobromite and hypochlorite methods in testing for urea," by L. E. Sayre.

"Long-continued blooming of Malvastrum coccineum," by Minnie Reed.

"Our Kansas mosses," by Minnie Reed.

"A freak in Solanum tuberosum," by D. S. Kelly.

"Notes on Kansas plants in the herbarium of the State Agricultural College," by A. S. Hitchcock. (Read by M. A. Carleton.)

The following papers were read by title:

"The Kansas river as a source of city water supply," by E. H. S. Bailey.

"On the composition of mineral water from the vicinity of the Great Spirit Spring," by E. H. S. Bailey and M. A. Rice.

"Telephonic communications between anchored vessels," by L. I. Blake.

"A geologic section along the Neosho river," by Erasmus Haworth.

"On the composition of a natural oil from Wilson county," by F. B. Dains.

"Coal in Atchison county," by E. B. Knerr.

"Some experimental telephonic and induction coils," by E. W. Caldwell.

"A method for producing rain artificially," by L. I. Blake.

"Inverse of conics and conicoids," by M. E. Rice.

"Notes on hypnotic suggestions," by Prof. Marvin and others.

The following new members were elected: Prof. H. S. Harnley, McPherson; Dr. S. Z. Sharp, McPherson; Prof. Erasmus Haworth, Lawrence; Prof. W. V. Ingham, Lecompton.

The following officers were elected for the ensuing year:

President, L. E. Sayre, Lawrence.

First Vice-President, I. D. Graham, Manhattan.

Second Vice-President, J. D. Hewitt, Emporia.

Secretary, E. B. Knerr, Atchison.

Treasurer, Dorman S. Kelly, Emporia.

Librarian, B. B. Smyth, Topeka.

Curators: A. H. Thompson, B. B. Smyth, C. S. Prosser, all of Topeka.

A resolution was passed extending the thanks of the Academy to Prof. Arthur Winslow for his entertaining and instructive lecture.

SMALL THINGS.

Address of the retiring President, PROF. E. H. S. BAILEY, Lawrence.

The Kansas Academy of Science last year celebrated its twenty-fifth anniversary. It is not a young nor a new institution in the state, for it has been identified with its growth and development. It has helped to increase that material wealth that is so important to the prosperity of a state. Its members have been looking into the ground to see what they could find that was of value; they have studied the animals and plants that were above the ground, to see which should be increased for the benefit of man, and which, like the pestiferous chinch-bug and the Canada thistle, should be eliminated and driven from the face of the earth, at least as far as Kansas was con-

cerned. This has been generous work—gratuitous work. The reward has come to the members of the Academy in seeing a more populous state, a more prosperons people, a more fruitful land.

In all the work that you have done you have been animated by the desire to pry into the secrets of nature, to find out her processes, to understand her laws. It is my purpose to recall to your mind one phase only of this work, and to direct your thoughts towards the part that has been played in this work and in the scientific investigation of the world by the so-called "little things."

The work of research has reached the advanced position which it now holds because those who have been most active in the great field of research, those who have been closest to the warm heart of nature, have not been satisfied with superficial observation alone, but have recorded the most minute and seemingly trivial things which they have seen. To do this has required labor, self sacrifice, and patience; patience cultivated to such a stage of perfection that it may almost be classed among the saintly virtues. The chemist and the physicist have pried between the atoms; the naturalist has examined and classified the infinitely minute creatures of earth, air and water, and the physician has followed the pathogenic or disease-producing germs to their original breeding places.

The great strength of scientific investigation then depends on the attention paid to details, and on the ability displayed towards getting at the very bottom fact—to the very smallest factor of the problem. And what are some of these small things that have helped to unravel the tangled web of the great world of nature?

First, in the realm of matter: Do we know anything of the constitution of matter? Matter can be infinitely divided or else there is a definite limit to the division. I may take a piece of chalk, for instance, and cut it into small pieces and each one of those pieces into smaller pieces, and so on forever, or if this it not possible, there will come a time in my division when the small particle obtained cannot be farther divided. This latter is the view now held in regard to matter—that there is a point beyond which its subdivision cannot go. Of course this point is infinitely below any possible mechanical division, and far below what the highest power of the microscope can reveal. That little particle of matter that is incapable of being cut or divided we call the atom. No one ever saw an atom; no one will ever see an atom, for it is infinite in smallness beyond our ken, just as there is an infinite greatness which we cannot comprehend.

Starting then with this atom: If we get two or more of them together, an aggregation of atoms, we call this a molecule. For according to the present theories these atoms are social beings; they seldom go wandering off alone. As Sothern so aptly says in regard to birds of a feather, "Of course they flock together; you don't suppose they would flock all alone, do you?" The atoms then are found in groups. Perhaps they recognize that there is greater safety in traveling in this way; less danger of being "held up."

But how large are these atoms, anyway? I need not perhaps remind you of the investigations that have been made on the size of the atom and of the molecule of which it is a part. From the work of Sir William Thomson on the electricity of contact of different metals, from a study of the surface tension and tne thickness of the soap-bubble film, and finally from what is known of the molecular motion of gases, a calculation has been made as to the distance apart of the particles of matter and as to their actual size.

From this we learn that the diameter of a particle is about one 250,000,000th of an inch, and therefore the number of particles in a cubic inch of air is not far from 3 raised to the tenth power, or (to represent this number more accurately to our comprehension) 3 with 20 ciphers annexed, thus: 300,000,000,000,000,000,000. Tait says that to get some understanding of it, we may say that one of the particles that go to make up a drop of water is to the whole drop as an ordinary base ball is to the whole size of the earth.

Perhaps I cannot better illustrate the extreme smallness of these particles than by dissolving a little of this coal-tar color known as fuchsin in some water. In this carboy there are 10 gallons or about 40 liters of water. I have weighed out, on a very delicate scale, four milligrams of this fuchsin. That is one 10,000,000th of the weight of the water in the carboy. I dissolve this dye stuff in alcohol for convenience and pour the solution into this carboy of water. You will notice the beautiful red or magenta color that is produced, and you will see that the whole quantity of water is reddened. This means that one part of the dye will color at least 10,000,000 parts of water. How very small must the molecules or particles be.

The chemical balance is the most important instrument that the analytical chemist or the investigator uses. With it he weighs ponderable matter, and the more accurate and the finer his weighings, the closer his results. Much progress has been made in the construction of balances, so that now the aluminum beam, the agate bearings and agate or steel knife edges, to avoid friction as much as possible, and finally the short arm balance, to facilitate rapid weighing, are common improvements to be found in every laboratory. The balance is inclosed in a glass air-tight case to avoid the inaccuracy that might be caused by draughts of air while weighing, and an artificially dried atmosphere is always present, so as to avoid the errors that might arise from excess of moisture. Moreover it is possible to pump out the air from a balance case and weigh in a vacuum, as is done in many of the finer physical and chemical investigations.

For greater cenvenience the decimal system of weights is used, and we say that we ordinarily weigh to the one-twentieth of a milligram. The scales are so delicate that they will fluctuate on the addition of a single hair to the load. I may illustrate this by balancing on the two pans of this scale pieces of paper of the same weight. You can see by the spot of light that is reflected on the wall from a mirror on the index that the beam is at rest as the support is lowered, and the beam is free to move up and down. The balance is then at equilibrium. Now I will write a name on this piece of paper with a lead pencil and replace the paper upon the pan. You see the result; the pan having the name written on the paper is heavier than the other. That shows the weight of a great name.

Dr. E. L. Nichols, a former president of this association, exhibited at the Madison meeting of the American Association for the Advancement of Science, this summer, some photographs that he had taken of the intermittent electric spark. For recording what takes place in infinitely small spaces of time, he makes use of the extreme sensibility of the photographic plate, and he makes the assertion that there is thus far no exposure too short to be recorded by it. By the use of this sensitive plate it is possible to photograph the rifle bullet at all stages of its passage through the air. It is possible to observe the condensation of the air that takes place in front of the advancing bullet, and the waves showing the vacuum behind it. We can study

also the effect on the bullet at the instant when it strikes the target, or at various stages of its passage through an oak plank.

Wheatstone has isolated by the revolving mirrors the one-millionth of a second, and the photographic plate records the phenomena that take place in these short intervals of time. They are accurately measured. With such delicate apparatus it is possible to record the history of the first three or four millionths of a second at the beginning of a phenomenon and also at the close. In this line what an inviting field for investigation.

What advances in study have become possible since Muybridge has succeeded so admirably in photographing animals in motion.

The waves of sound are considered to be coarse waves. They require air for their propagation. Pump all the air out of this room and you might ring the great bell of Moscow and no sound would be heard. Has it not occurred to all there are sounds both too high and too low for us to recognize with the hearing apparatus with which we are endowed? Our ability in this direction depends on the delicacy of the organs of hearing. We hear some of the sounds that agitate the air, but how many sounds are there so exquisitely fine that they are never heard? You can hear the voice of the mosquito as fine as a cambric needle, but is that not nearly at the end of your scale? What a vast orchestra may be playing about us at this very moment, while their music is as completely lost as the fourteenthly of the pastor's sermon upon the sleeping deacon. These are the little sounds. We may sometime invent instruments suitable to enable us to detect the unheard sounds.

The deep tones of nature can be heard and appreciated by some better than by others. The roar of Niagara and the crash of the avalanche is the sublimest of music if we hear it aright. We must catch the harmonic tones of the cataract's roar and the dying echoes of the crashing ice torrents as they are hurled from the icy walls of the mountain valley.

But we should not call upon the sense of sight and of hearing alone to testify to the capacity of the human body for minute investigation. The sense of smell and the sense of taste have been too long neglected. We have continual evidence of the delicacy of the sense of smell. I need not refer you to the oft quoted assertion that a grain of musk will scent a room for a score of years, and yet not lose appreciably in weight. Still, can we account for the dissemination of this odor on any other theory than that the minute particles have actually left the original grain of musk and are floating about in the air? We cannot catch them nor weigh them, yet the nose will tell us where the sweet or disagreeable odor is, and it is an unfailing monitor. In the present state of development of this sense, however, the lower animals far outdo man. But this greater sensitiveness is without doubt largely due to the more extensive use of the organ of smell by the lower animal. Man has cultivated the sense of sight and of hearing; he has learned to appreciate the beautiful in art and in music, but he has regarded as entirely beneath his notice those senses that contribute so much to his happiness. What will recall the old home kitchen more quickly than a whiff of some long-forgotten odor? Can you ever smell the fragrant hickory-nut shell without being reminded of the tall tree you boys used to climb in the mellow October Saturday afternoons? Can you smell the old-fashioned marigold or four-o'clock without seeing some kitchen garden tended by a spinster aunt of your acquaintance?

There are no senses that are quicker to respond to suggestions than these

so intimately associated ones. We express this in common conversation, when we associate the Irishman with his peat fire smoke, the Italian with his macaroni and cheese, and the German with his onions and sour beer. These appeal to our sense of smell and recall the nationality instantly.

The nerves of taste, too, can pick out substances of different quality so delicate that neither chemical nor physical science is acute enough to follow them. From some experiments made in the laboratory of the State University, it has been shown that a normally-endowed person can pick out one part of a bitter substance in about 700,000 parts of water; but one part of sugar in 128 parts of water is the limit of sensibility. There are those, however, who, either from superior training or from natural delicacy of the sense, can detect one part of a bitter substance even if it is dissolved in a million and a quarter parts of water. They can detect one 170,000th part of a grain of strychnin, for instance. That is beyond the delicacy of the chemical test for this poison, but not very much beyond it. And it must be remembered that the chemical test says that the substance is strychnin, while the taste only tells us that the substance is bitter. It may be any bitter principle, as aloin, morphin, or quinin.

In the field of Toxicology, also, as we have a knowledge of poisons, minute quantities of which are fatal, we have also extremely delicate methods for the detection of these poisons. One is reminded in this science of the progress that is made in building huge projectiles and in heavier armor to withstand the force of the projectiles. With the Krupp gun comes the 10-inch chilled steel for it to penetrate. With the increase in projectile power comes the greater ability to withstand these projectiles. We cannot tell why that molecule $C_{21} H_{22} N_2 O_2$, which we call strychnin, has such deadly power, but we can find it even if it is present in very minute quantities in the body. From a mass of organic matter many thousand times the amount, it is possible to separate, after repeated purifications, the pure needle-shaped crystals of strychnin, that may be identified by a dozen distinct and characteristic tests. We can go out of the line of chemical investigation and make physiological tests that will verify our results from another standpoint. I have experimented with a frog, for instance, by injecting less than one 125th of a grain beneath the skin, and seen the peculiar spasms so characteristic of this poison appear in less than a minute, and in three minutes the frog was dead. This was with strychnin that had been taken from the body of a man who had been poisoned by a fatal dose.

There is also another deadly drug, aconite, so poisonous that a still smaller portion than that noticed for strychnin is liable to prove a fatal dose. Here, too, the physiological test can be relied upon with certainty. It is stated that if one 1,000th of a grain of this alkaloid be dissolved in water and placed upon the tongue it will cause a distinct numbness that will last for an hour, while one 100th of a grain dissolved in alcohol and rubbed on the skin will produce loss of feeling that will last for some time. Experiments have shown that one 50th of a grain given to a bird will kill it almost instantly.

I need not speak of that interesting active substance, atropin, which the oculist will inject into your eye when he examines it. We know that as small a quantity as one 3,000th of a grain will dilate the pupil. Here then we have a delicate and efficient test for this drug.

In the field of organic chemistry the advances that have been made are

wonderful. One of the most interesting substances that has been discovered is saccharin. It is made, as are the anilin colors, from coal tar. It is several hundred times as sweet as sugar; so that, if a small particle be placed on the tongue, the impression of sweetness will remain for a long time. If any of you want to go forth as apostles of sweetness and light, you can be fitted out from the chemical laboratory, and can go forth with a bottle of saccharin in one hand and a coil of magnesium ribbon in the other. You can thus sweeten the walks of men and light their paths in a purely physical sense.

It is appropriate that I should speak of some of the most delicate physical and chemical methods used in making tests.

One of the most delicate instruments is the spectroscope, the invention of Kirchoff and Bunsen. Without going into details as to the construction of the instrument, it is only necessary to say that by its use it is possible to analyze the light from a heated metal, from the sun, or from the most remote fixed star or comet, and tell of what it is composed.

One of the commonest substances on the earth is common salt, sodium chloride. We have an immense storehouse of it in the water of the ocean, and it is found deposited in great beds in several favored localities, of which central Kansas is one. When sodium, the metal of salt, burns, it imparts to the flame a yellow tint. This can be seen on a large scale if I light a bowl of alcohol that is saturated with salt. You will notice the peculiar cadaverous effect that the light produces on all objects in the vicinity.

By the use of the spectroscope it is possible to detect an almost infinitely small quantity of this substance. It is estimated that one 195,000,000th of a grain can be detected. A grain is about as much as would lie on the point of a pen-knife. That is considerably less than a "pinch." Lithium, too, has a characteristic flame reaction.

The chemist can avail himself also of very delicate tests for ammonia; and he finds these tests of the greatest use in the determination of the extremely small quantities of ammonia in air and in water. Yet these tests in water are of great importance to the analyst in helping him to decide as to the purity of a water and whether it is fit for use as a domestic supply. One of these tests is by the use of "Nessler's solution," as it is called. By its use we can detect the one 1,000,000th of a grain, or, to be more practical, we can detect one part of ammonia in 100,000,000 parts of water.

In an interesting article on "Next to Nothingness in Chemistry," W. H. Pendlebury speaks of some of the latest discoveries that have been made in the importance of little things. It is wonderful, for instance, what an effect moisture has on the simple process of combustion. Even the ordinary coal or wood fire does not burn well if the fuel and the air are perfectly dry. It has been shown that if oxygen be perfectly dry, such a combustible substance as phosphorus may be warmed, or even distilled in it, and not take fire. Wanklyn has discovered that dry chlorin will not combine with dry oxygen; but, if the least particle of moisture be admitted, the combination takes place immediately with the evolution of light and heat.

It has been shown that copper does not act on nitric acid, if both are pure; but the smallest trace of nitrous acid will bring about the combination with avidity. One part of nitrous acid in 10,000 is sufficient.

What a vast difference the presence of a little impurity can make in commercial copper. It will carry twice as many messages used as a telegraph wire if pure as if adulterated with even one-tenth of 1 per cent. of bismuth.

One 1,000th part of antimony in copper will destroy its value for many commercial purposes.

Steel is perhaps as sensitive to small quantities of carbon as any metal that can be mentioned. Look at that strong boiler plate: it is made of a steel that contains perhaps two-tenths of 1 per cent. of carbon. This kinfe is made of a steel that contains perhaps eight-tenths of 1 per cent. But it would be impracticable to make a boiler plate out of this knife steel.

We are all more or less familiar with the substance known as gold leaf. Gold is the most malleable of metals, so that if I pile up 200,000 leaves of gold one above another the pile will be only one inch high. It is so thin that it floats almost in the air, yet really the metal is 19.5 times as heavy as water. If then I have a vessel of water on this table that weighs 100 pounds the same vessel filled with gold would weigh 1,950 pounds, or almost a ton.

Gold is very susceptible to a small amount of impurity. One part in 2,000 would make it so brittle that a bar of it would be readily broken with a hammer. This is in the face of the fact as I stated that it is when pure the most malleable of metals. Our predecessors, the alchemists, understood the wonderful effect of a small quantity of another metal upon this precious metal, and is it any wonder that they sought to find a philosopher's stone that would change a common metal to gold?

A large amount of work has recently been done on the micro-organisms of the soil; those infinitesimal creatures that have their home and do their work in the darkness below the surface of the earth. Some of these bacteria are very curious in their habits as well as very small. There is one, for instance, that actually needs carbonate of iron in order to keep in good growing condition. It gives off oxygen that it has abstracted from the iron compound. We hear much just now of the great corporations swallowing the railroads, but given an unlimited cycle of years, as our geologists say, and an infinite number of bacteria, and they will also swallow the railroads—at least the rails.

You have perhaps heard also of those wonderful "nitrifying ferments," which have been so successfully studied by Warrington and by Winegrawdski. One of these is an organism which can grow and work in the dark in material that actually contains no organic material. Here it can produce organic bodies, using the ammonia of the soil and the carbon of the carbonates. Another ferment has the power to change the organic nitrogen of the soil to ammonia.

The agricultural chemist will tell you of organisms that actually add nitrogen to the soil. Though there is an abundance of nitrogen in the air, in fact four-fifths of the air in this room is nitrogen, yet most plants have not the ability to use it. The leguminous plants, however, are an exception to this rule; but they cannot do the work without calling to their aid some of those little bacteria that I mentioned. Did you ever notice the knotted root of the clover? It is supposed that these tubercles or knots are produced by exterior infection. In fact this is proved by the simple test of attempting to grow lupines in a soil of pure sand. They will starve; but if the plants are watered with a fresh extract made from lupines, then the little tubercles will be produced and they have the power to assimilate the nitrogen from the air, and the plants will thrive.

It is well known, to those who have kept apace with what is going on in the agricultural world, that not only is the farmer under obligations to one microscopic forms of life for the fertility of his soil, but in the domestic

operations of butter and cheese making he must call to his aid these mysterious allies. He is obliged to depend on these minute organisms for the production of the "gilt-edged butter" that always commands the highest price in the market. The Danes, whose exhibit at the World's Fair was a revelation to some of us, have done as much as any people towards the isolation and perpetuation of those particular forms of bacteria that have been found to produce the best, sweetest butter. As a result of their work, "prepared cultures" are now offered to dairies. If they have allowed their stock of bacteria to degenerate; if through lack of care or of cleanliness their particular families of bacteria are not the best that can be had, all that it is necessary to do is to sow in the dairy some of these good, healthy colonies and good, sweet grass butter can again be made. Our grandmōthers did not suppose that when they watched so carefully the temperature of the cream, and when they attended so carefully to the cleansing of the milk pans, that they were only producing conditions for the healthful growth of those bacteria that had "blue blood" in their veins, and those that would scorn to aid in the manufacture of anything but the highest grade of butter.

So also in cheese ripening. It makes the greatest difference what colonies of these lower organisms are admitted into the factory. Some will only bring discord and moldy cheese; others sweet, ripe old age .

It would be interesting to illustrate the subject farther by more glances into the under world of bacteriology that has begun to open out so wonderfully within the past few years to the eye of the patient investigator. What immense results may be expected from the work in this field, following the lead of such men as Koch and Pasteur? We have learned to identify with reasonable certainty the germs of consumption, of cholera, and of typhoid fever; and now the next step obviously is to study tne conditions of their propagation and growth; and, knowing their life history, we shall be better able to guard against their attacks. But, however seductive this field is, we must leave it with only these few glimpses.

Finally, be it noted that all those who are engaged in the work of scientific investigation are adding to the sum of human knowledge, each in his narrow sphere, it may be, but each just as effectively. We cannot afford to look on anything that can be seen or heard or felt or tasted or smelled or known as too small or too insignificant for our notice. It is only in following out the little clews that we may chance to get hold of that we can hope to solve the labyrinth of nature. The true investigator never despises the "day of small things."